NGA-West2 Research Program

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NGA-West1

- **NGA-West1 (Original NGA Project)**
  - PEER compiled a very comprehensive **database** of ground motions recorded in **shallow crustal earthquakes in active tectonic regions**
  - Numerous **supporting research studies** were also carried out
  - In 2008, Next Generation Attenuation (**NGA**) ground motion prediction equations (**GMPEs**) were developed
  - USGS adopted the NGA-West1 GMPEs for the US National Seismic Hazard Maps
  - **NGA-West2 is a follow-up of NGA-West1**

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Sponsors of NGA-West2

- Supports of the sponsors are appreciated

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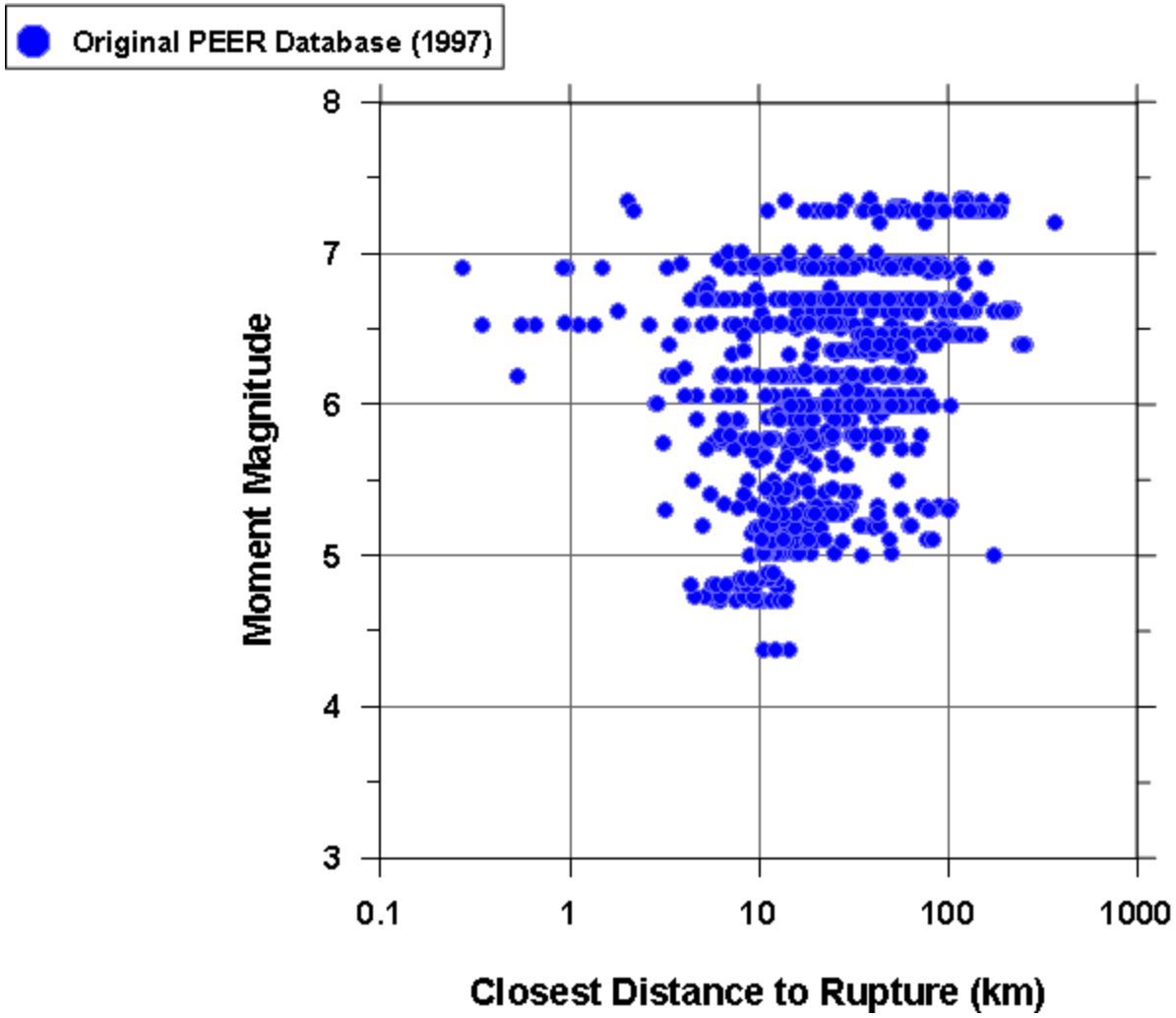
NGA-West2 Sub-Projects

Update worldwide database



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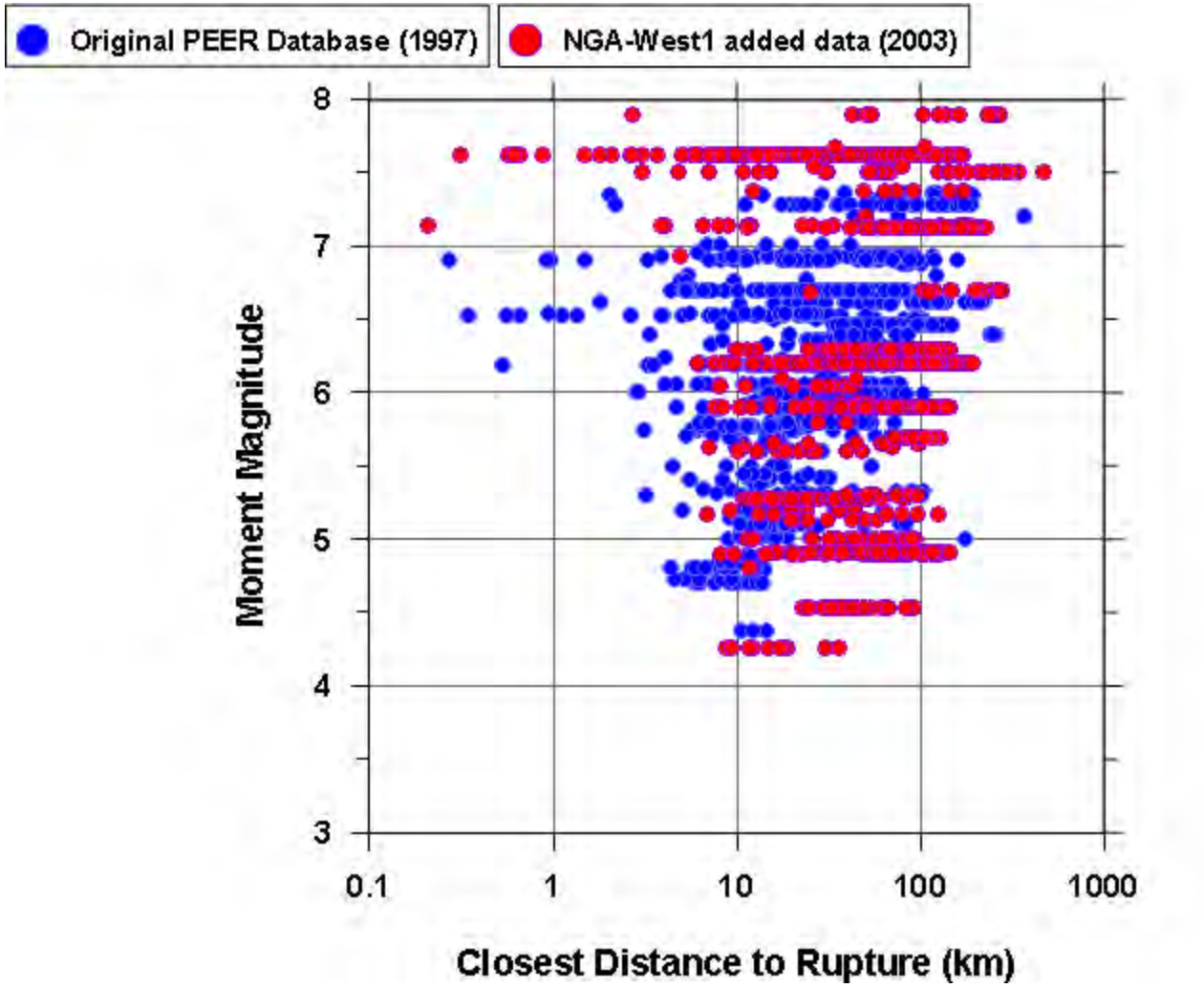
Update worldwide database



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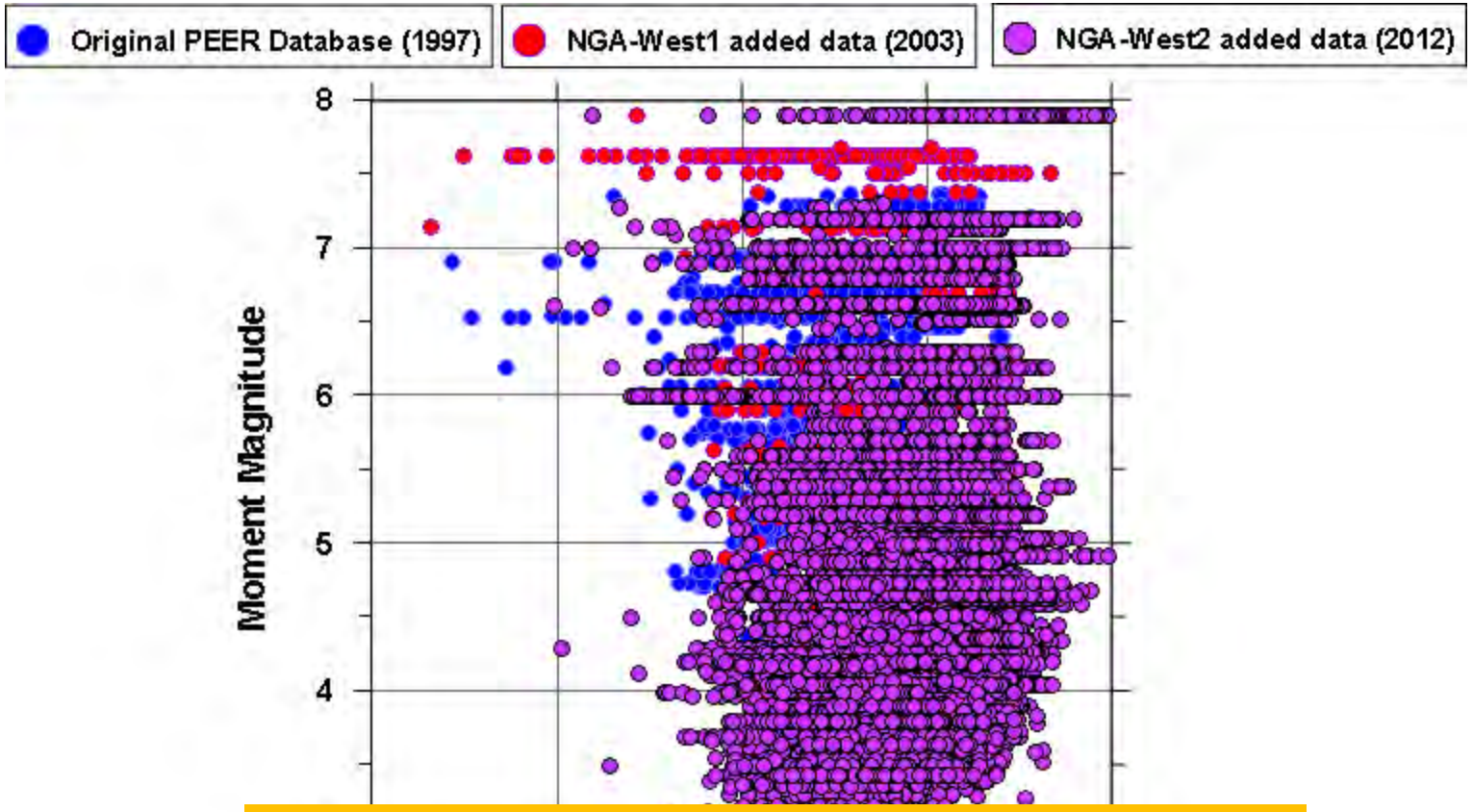
Update worldwide database



NGA-West2 database includes over 19,000 three-component recordings… over 57,000 records

From NGA-West1 to NGA-West2 the size of database was increased by a factor of 5.5

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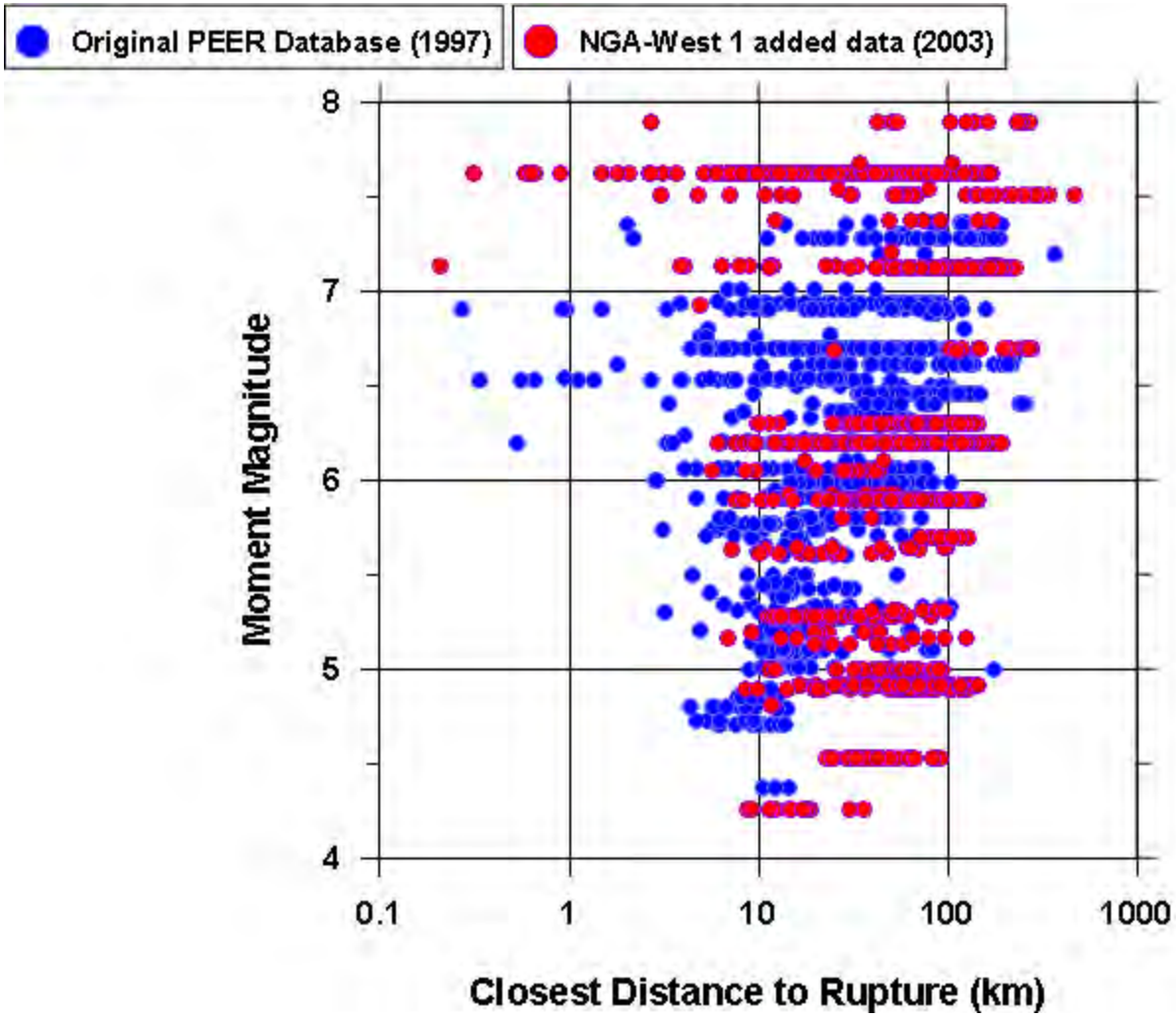
Moderate-to-large magnitude worldwide database



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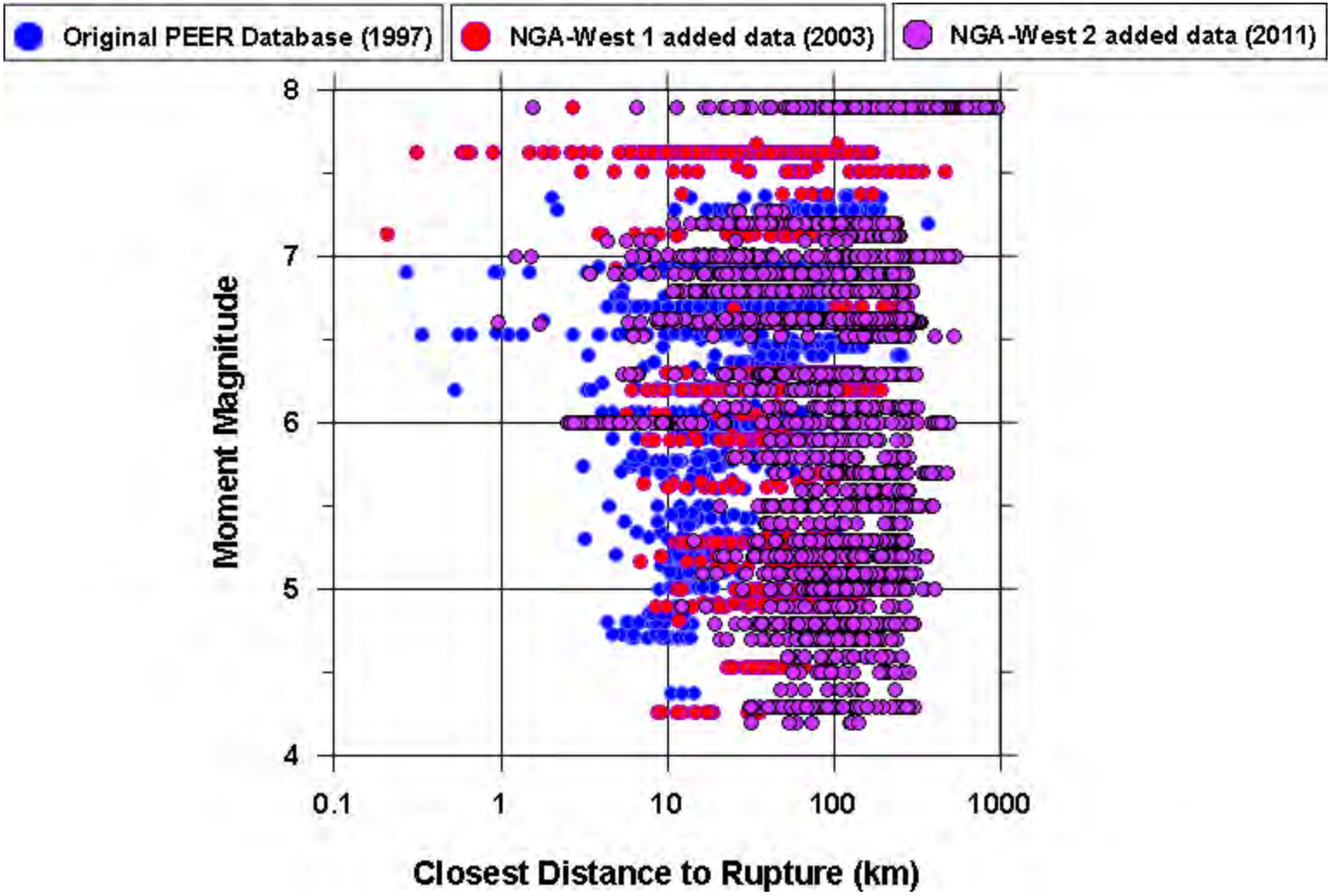
Moderate-to-large magnitude worldwide database



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Examples of data added to NGA-West2 database

Earthquake Name*	Year	M	N Rec	Rrup Range (km)
Tottori, Japan	2000	6.61	414	1-333
Niigata, Japan	2004	6.63	530	8-300
Chuetsu-oki, Japan	2007	6.8	616	10-300
Iwate, Japan	2008	6.9	367	5-280
El Mayor-Cucapah, CA	2010	7.2	238	11-240
Darfield, New Zealand	2010	7	114	1-540
Christchurch, New Zealand	2011	6.1	104	2-440
Wenchuan, China	2008	7.9	263	1-1500
L'Aquila, Italy	2009	6.3	48	5-230

*subset of added events

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Comparison of NGA-West1 & NGA-West2 databases

Data Set	# EQs	# Rec	Sa Type	Damping	Periods (sec)
NGA-West1	173	3,551	AR, GMRotI50	5%	0.01 - 10
NGA-West2	610	19,400	AR, RotDnn	0.5-30%	0.01 - 20

AR= As-recorded

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RotDnn definition

- At each period, rotate horiz. components,
- RotD**50** = 50 percentile,
- RotD**100** = **max**,
- RotD**00** = **min**
- Motivation: Users can use the maximum rotated motion

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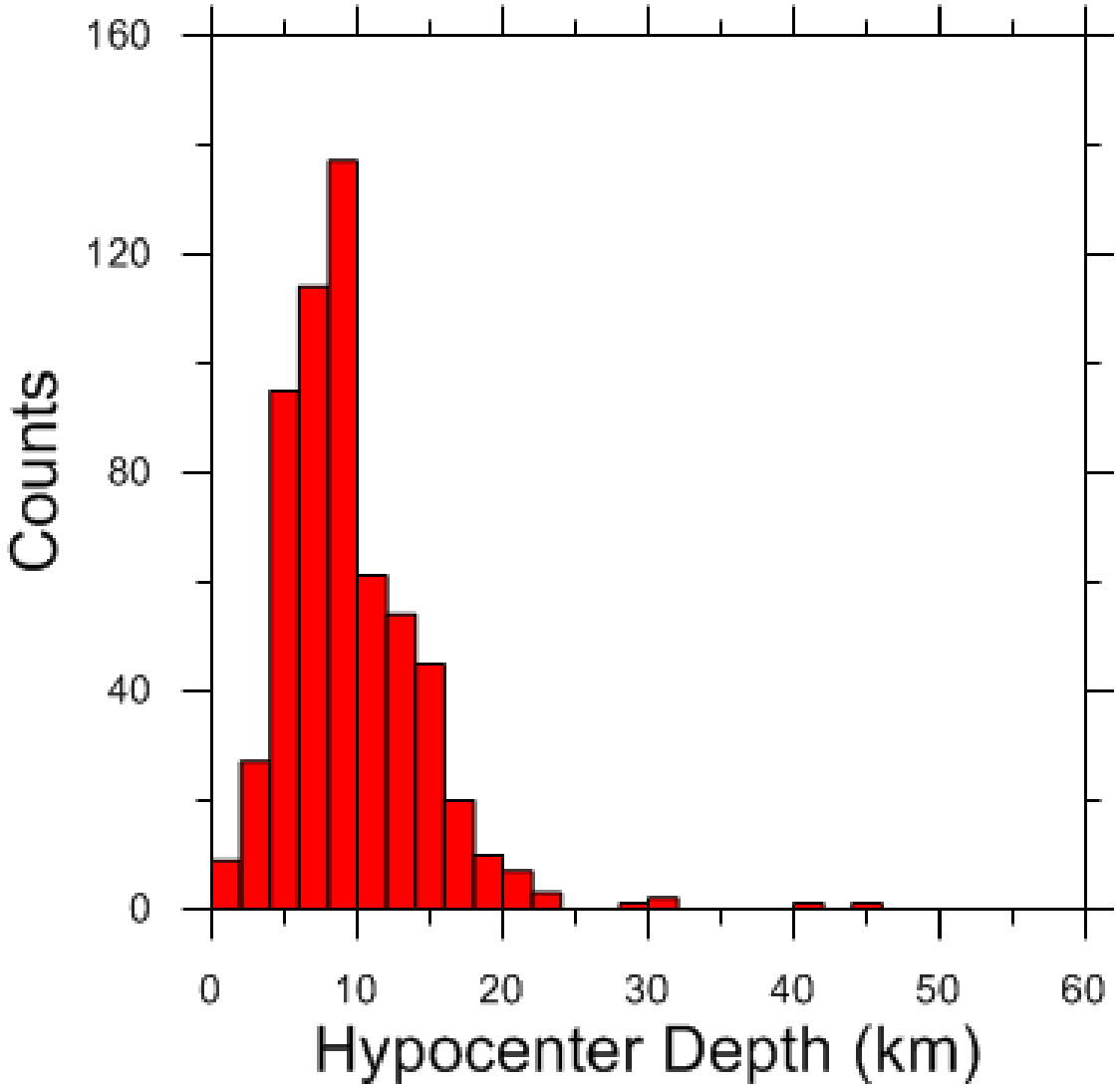
NGA-West2 Distribution of Hypo Depth in the Database



Courtesy: Tim Ancheta

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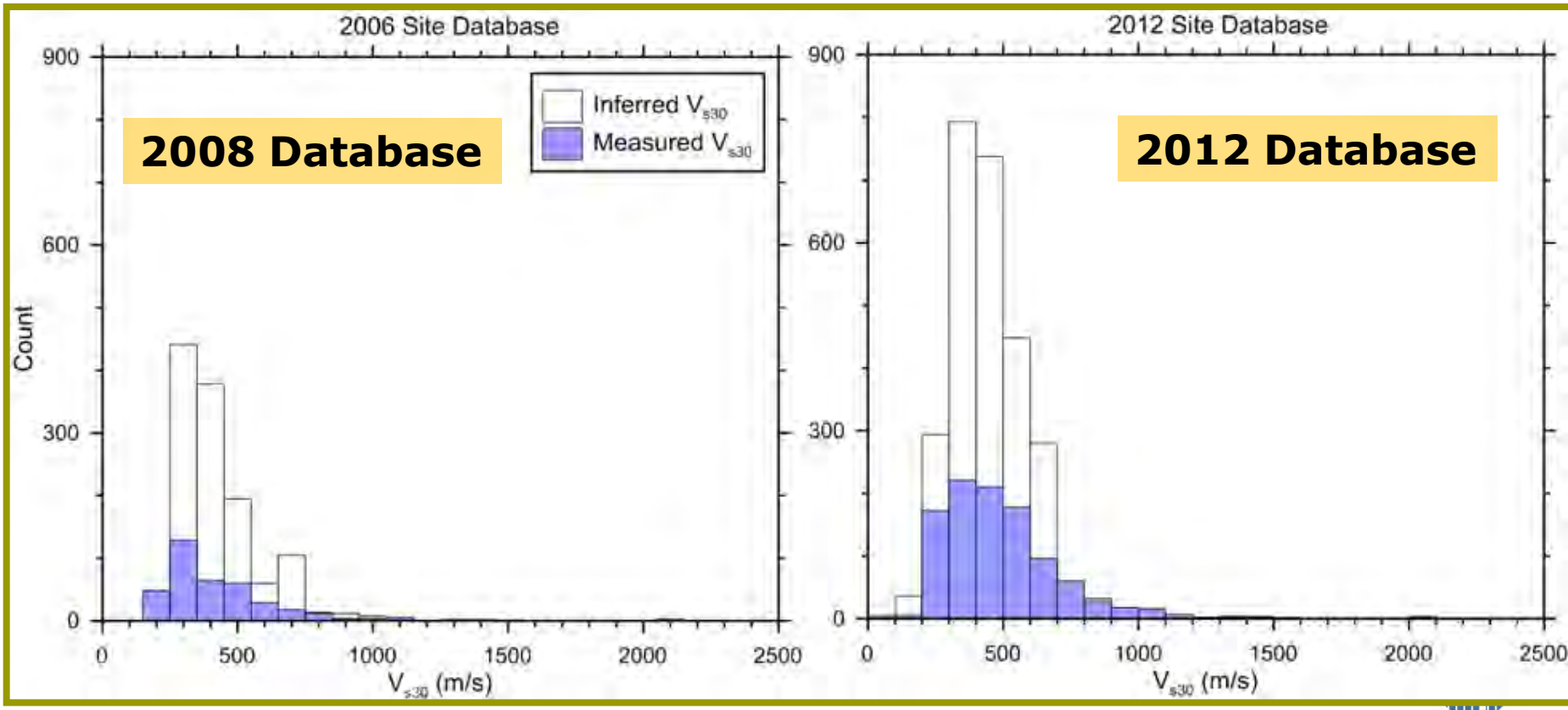
Vs30 distribution

- Measurements versus inferred values (estimated by various methods such as slop, geology,…)



Courtesy: Jon Stewart

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Why did we add small magnitude data?

- **Motivation**:
  - NGA-West1 models over-predicted motions for small magnitude
  - In the future, we can analyze multiple events recorded at same site to characterize the site variability (single-station Sigma)
  - In the regions that have mainly small magnitude data, they can compare NGA with their data

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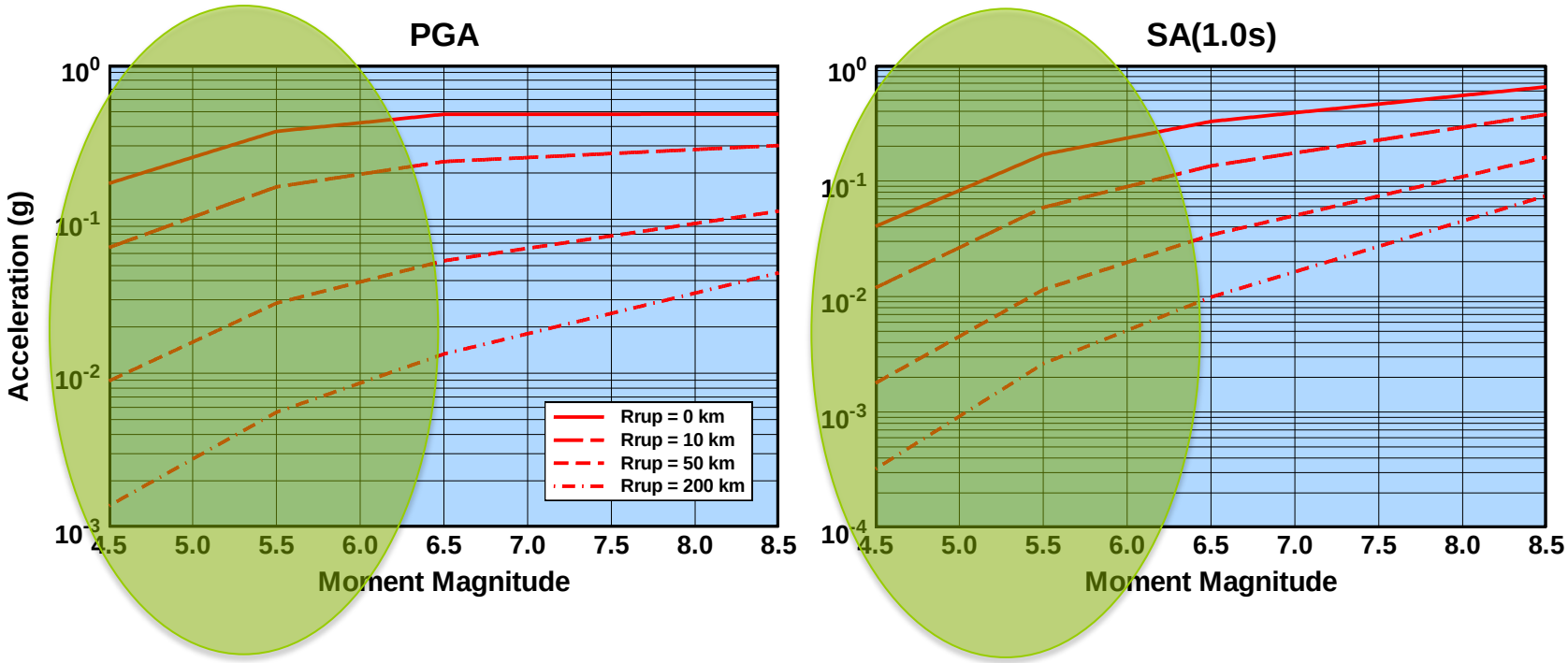
Magnitude scaling at small magnitude



Update NGA GMPEs for horizontal motion

- Using the latest database
- Using supporting research on:
  - Directivity of ground motion
  - HW/FW model using simulations data
  - Update of nonlinear soil response
  - New classification of “main shock” vs “aftershocks”
  - …

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Model Parameters

Parameter	AS	BSSA	CB	CY	Id
Magnitude	Mw	Mw	Mw	Mw	Mw
Top of Rupture	Z_{tor}		Z_{tor}	Z_{tor}	
Style of Faulting	RV,NM,SS	RV,NM, SS	RV,NM, SS	RV,NM, SS	RV,NM, SS
Dip	Yes		Yes	Yes	
Downdip Fault Width	Yes		Yes		
Closest Distance to Rupture	R_{rup}		R_{rup}	R_{rup}	R_{rup}
Hor Dist. to Surface Proj.	R_{jb}	R_{jb}	R_{jb}	R_{jb}	
Hor Dist. perpendicular to Strike	R_x, R_y		R_x	R_x	
Hanging Wall Model	Yes	(R_{jb})	Yes	Yes	
Vs30m	Vs30	(760m/s)	Vs30, (S_j)	Vs30	Vs30≥450
Depth to Vs	$Z_{1.0}$		$Z_{2.5}$	$Z_{1.0}$	
Hypocentral Depth			H_{hyp}		
Vs30m for Reference Rock	1100	760	1100	1130	

Courtesy: Nick Gregor

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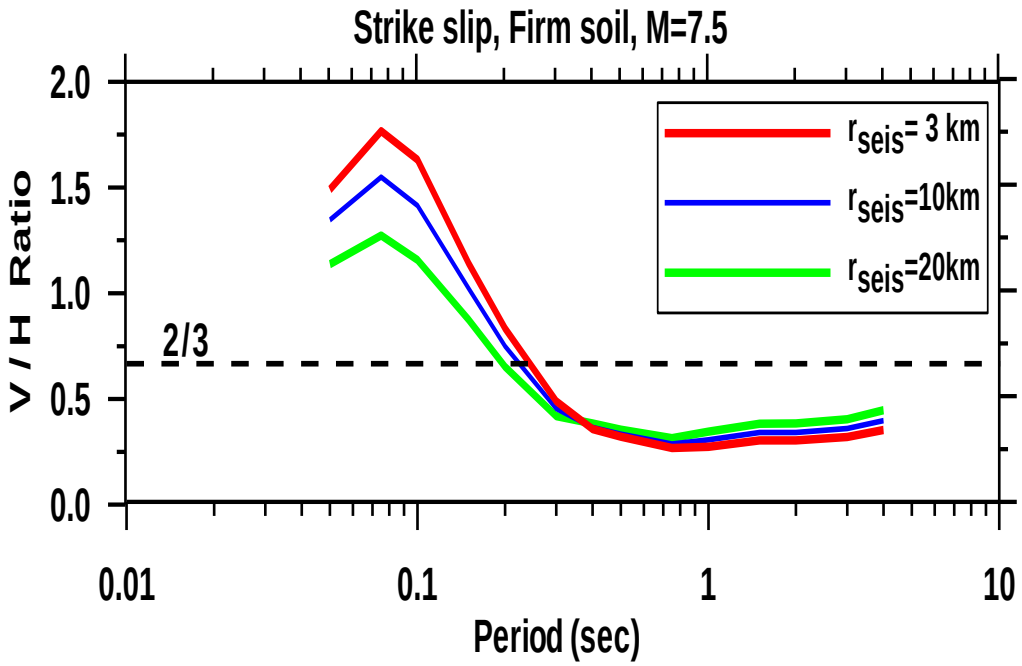
Develop GMPEs for vertical component

- NGA-West1 models predicted only horizontal ground motions
- Recorded data have shown that vertical ground motion can be large at the sites close to active faults



Do not use 2/3 to scale horizontal motion to get vertical

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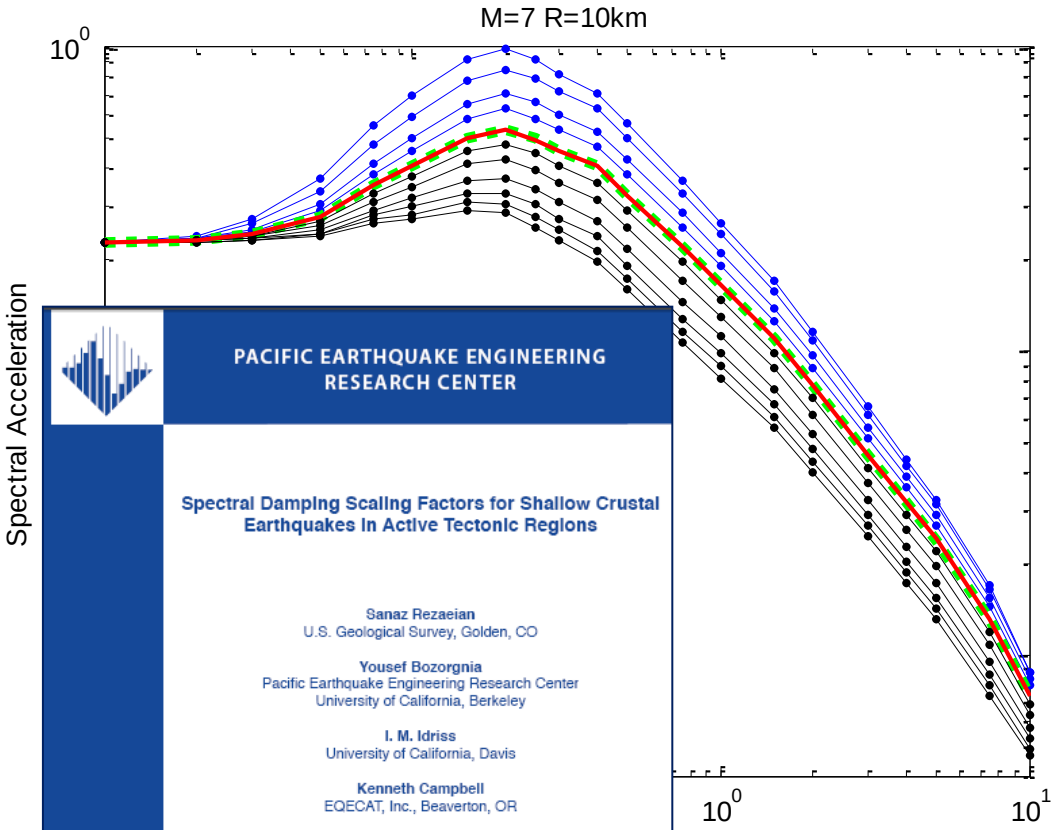
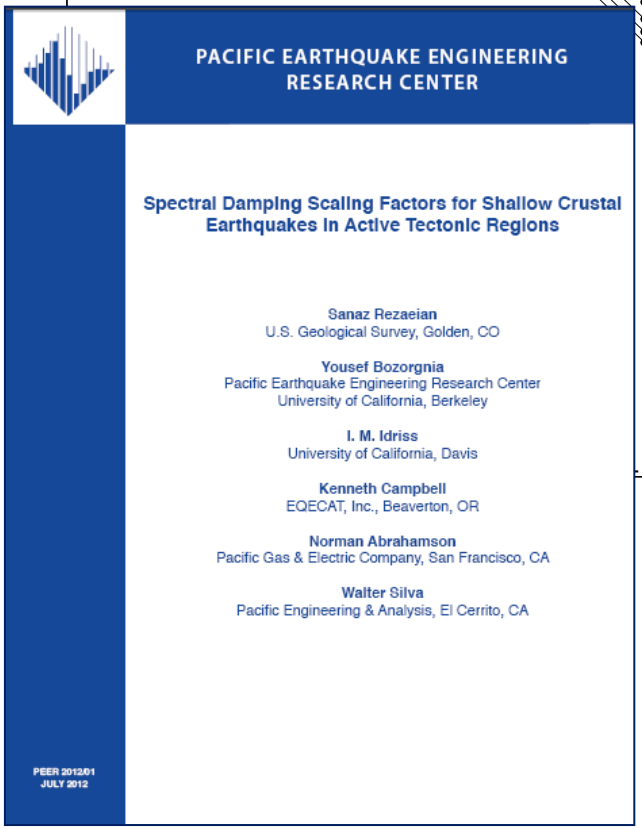
Damping scaling of response spectra

- Scale GMPEs for damping other than 5%:

  0.5% to **30%**

- Damping scaling model is final; PEER report already published





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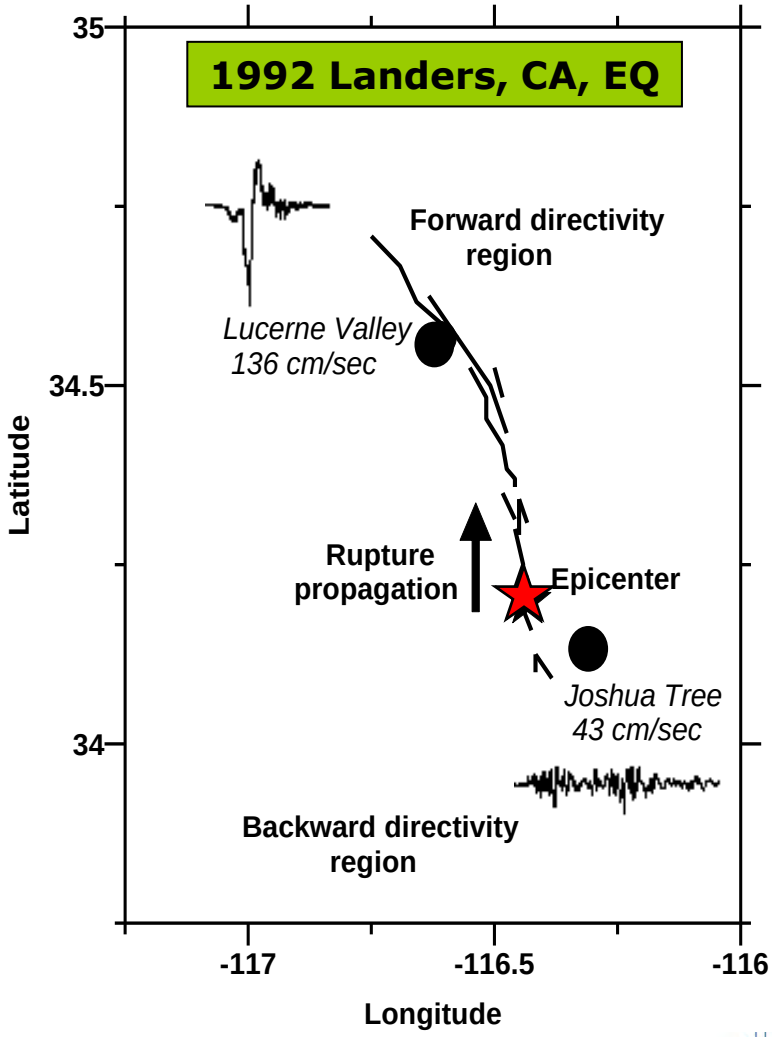
Directivity

- NGA-West1 models did not explicitly include directivity of ground motion
- Five directivity models have been developed
  - Wide-band and narrow-band models
- Effects of directivity will be included in NGA-West2 GMPEs



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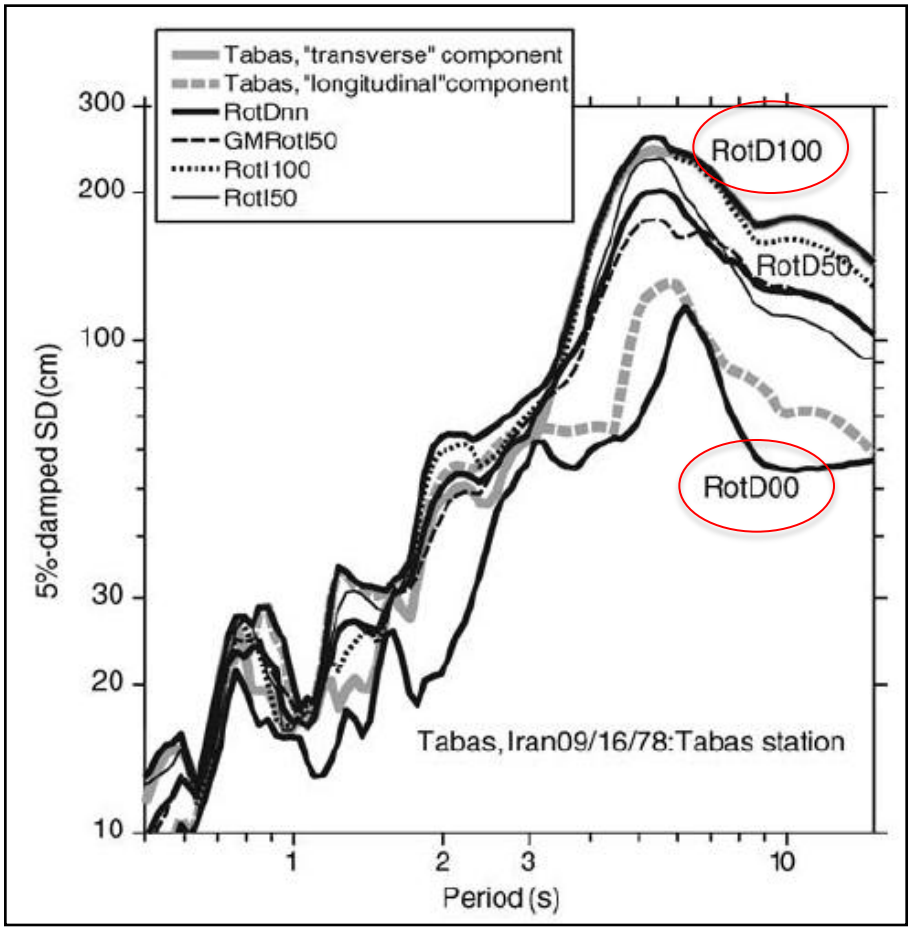
Directionality (Polarization)

- NGA models are for "geometric mean" horizontal components
- Develop max and min rotated spectra, as a function of mag, distance,…
- Examine relationship of max/min spectra with RotD50 (50 percentile) spectra



Ref: Boore (2010)

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Epistemic uncertainty model

- Develop epistemic uncertainty model for NGA-West2
- Will need final GMPEs
- Will be carried out by January 31, 2013

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Site Response

- NGA-West1 site amplification factors are inconsistent with NEHRP site amplification factors
- Goal: To make NEHRP and NGA site amplifications consistent
  - Propose changes in NEHRP factors
- This is both scientific and consensus-building task

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NGA-West2 Status

- Some tasks have already been completed
  - Databases, damping scaling, directivity, directionality, site response
  - Draft final reports are being reviewed internally and externally
- Draft of GMPEs for horizontal components are ready for review to obtain:
  - Feedback from the USGS National Hazard Maps, internal and external reviewers

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NGA-West2 Status (cont'd)

- Draft final reports on horizontal and vertical GMPEs and epistemic uncertainty will be sent to the sponsors and reviewers by January 31, 2012
- Obtain comments on draft report: February 28, 2013
- Finalize all reports for public release: April 15, 2013

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Many people have been involved in NGA-West2

- **Technical Coordination Committee**:
  - Abrahamson, Bozorgnia, Campbell
- **External reviewers and oversight committee**:
  - Chris Wills, Mark Petersen, John Anderson, Roger Borcherdt, Silvia Mazzoni, Farzad Naeim
- **Funding agencies representatives:**
  - Badie Rowshandel & Tom Shantz

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People involved in NGA-West2 per Tasks

- **Database**: Ancheta, Darragh, Chiou, Silva, Stewart, Seyhan, Graves, Wooddell, Katke, Boore, Kishida, Al Atik, NGA developers
- **GMPE Developers**:
  - Abrahamson & Silva
  - Campbell & Bozorgnia
  - Chiou & Youngs
  - Boore-Stewart-Seyhan-Atkinson
  - Idriss
- **Damping:** Rezaeian, Bozorgnia, Idriss, Abrahamson, Campbell, Silva & GMPE developers

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People involved in NGA-West2 per Tasks (Cont'd)

- **Vertical:** GMPE developers
- **Directivity:** Spudich, Chiou, Baker, Shahi, Rowshandel, Somerville, Bayless, Watson-Lamprey & GMPE developers
- **Directionality:** Baker, Shahi, & directivity group
- **Site Response:** Stewart, Seyhan, Anderson, Borcherdt, Crouse, Graves, Idriss, Power, Silva, Shantz

Putting together pieces of a complicated puzzle through a large coordinated multidisciplinary Team Work

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THANK YOU!